

PURDUE PESTICIDE PROGRAMS

Purdue University Cooperative Extension Service

PESTICIDES AND FORMULATION TECHNOLOGY

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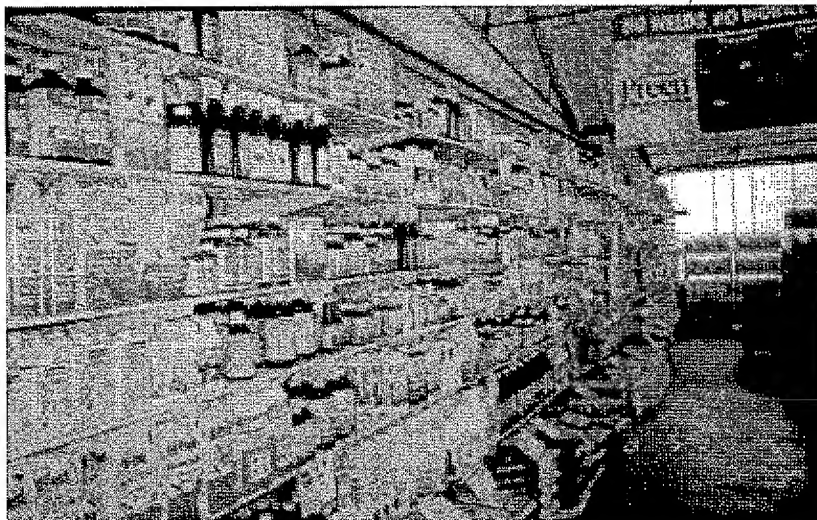
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PESTICIDE PRODUCTS AND THE MODERN MARKETPLACE

There is a seemingly endless variety of pesticide products sold in the urban and agricultural marketplace. Casual observation in any hardware store or lawn and garden center will reveal that variations extend even to products that are manufactured by the same chemical company and contain the same ingredients.



Manufacturers often produce various forms of a pesticide to meet different pest control needs. For example, an insecticide may be applied as a liquid to control adult Japanese beetles on rose bushes and as a solid material for suppressing the larval (grub) stage of that insect in turf. Applying the insecticide as a liquid spray permits contact with the adult beetle, while the solid form can be watered into the root zone of the lawn where the grubs live.

A pesticide product consists of two parts: active and inert ingredients. Active ingredients are chemicals which actually control the pest. Inert ingredients are primarily solvents and carriers that help deliver the active ingredients to the target pest; they serve to enhance the utility of the product. Inert ingredients may be liquids into which the active ingredient is dissolved, chemicals that keep the product from separating or settling, and even compounds that help secure the pesticide to its target after application.

The combination of an active ingredient with a compatible inert ingredient is referred to as a formulation. Pesticides are formulated for a number of

different reasons. A pesticide active ingredient in a relatively pure form, ready for manufacturer's use, rarely is suitable for field application. An active ingredient usually must be formulated in a manner that

- increases pesticide effectiveness in the field
- improves safety features
- enhances handling qualities

The formulation gives the product its unique physical form and specific characteristics, enabling it to fill a market niche. There are approximately 860 pesticide active ingredients formulated into 21,000 pesticide products sold and used in the United States today. For most practical purposes, the terms *formulation* and *product* can be used interchangeably.

AN OVERVIEW OF THE FORMULATION PROCESS

The active ingredients in pesticide products come from many sources. Some, such as nicotine, pyrethrum, and rotenone, are extracted from plants. Others have a mineral origin, while a few are derived from microbes. However, the vast majority of active ingredients are synthesized in the laboratory. These synthetic active ingredients may have been designed by an organic chemist or discovered through a screening process of chemicals generated by various industries.

Regardless of their source, pesticide active ingredients have different solubilities. Some dissolve readily in water, others only in oils. Some active ingredients may be relatively insoluble in either water or oils. These different solubility characteristics, coupled with the intended use of the pesticide, in large measure define the types of formulations in which the active ingredient may be delivered.

It is preferable from the manufacturer's perspective to use the active ingredient in original form, when possible (e.g., a water soluble active ingredient formulated as a water soluble concentrate). When this is not feasible, it may become necessary to alter the active ingredient in order to change its solubility characteristics. This would be done, obviously, in a manner that did not detract from the pesticidal properties of the active ingredient.

Usually, an active ingredient will be combined with appropriate inert materials prior to packaging. A brief review of some basic chemistry terminology should prove helpful in understanding differences among the various types of formulations.

Example: 2,4-D

The herbicide 2,4-D (2,4-dichlorophenoxyacetic acid), in purified form, is a white, crystalline solid. It is an organic acid that is not particularly soluble in water or oil. For this reason, the acid form of 2,4-D has not seen much use in commercially available products.

Generally, the acid form of 2,4-D is combined with a base. Bases neutralize acids and the resulting product is a salt and water. In this case, a salt of 2,4-D is generated. Most salts of 2,4-D are water soluble.

Finally, the acid form of 2,4-D can be combined with an alcohol to create a 2,4-D ester; 2,4-D esters are oil soluble liquids.

In this manner, the herbicide 2,4-D can be altered to change its solubility characteristics and ultimately permit the development of a number of formulations far beyond those available through the use of the acid form.

Sorption

In some cases it may be necessary or desirable to adhere a liquid active ingredient onto a solid surface (e.g., a powder, dust, or granule). This process is called *sorption* and it can be accomplished by two possible mechanisms:

- Adsorption—a chemical/physical attraction between the active ingredient and the surface of the solid.
- Absorption—entry of the active ingredient into the pores of the solid.

Solution

A solution results when a substance (the solute) is *dissolved* in a liquid (the solvent). The solute can be a solid, a liquid, or a gas. The components of a true solution cannot be mechanically separated. Once mixed, a true solution does not require agitation to keep its various parts from settling. Solutions are frequently transparent, although if they are darkly colored this may not be the case. An example of a solution is the active ingredient in the herbicide Gramoxone®: paraquat (solute) dissolved in water (solvent).

Suspension

A suspension is a mixture of finely divided, solid particles *dispersed* in a liquid. The solid particles do not dissolve in the liquid, and the mixture must be agitated to maintain thorough distribution. Most suspensions will have a cloudy appearance. The herbicide AAtrex 4L® is formulated as a suspension. The label directs the user to shake well before using. This product also forms a suspension when mixed with water for application as a spray. Explicit label information describes the need for sufficient agitation to keep the product dispersed in the spray tank.

Emulsion

An emulsion is a mixture that occurs when one liquid is *dispersed* (as droplets) in another liquid. Each liquid will retain its original identity and some degree of agitation generally is required to keep the emulsion from separating. Emulsions usually will have a "milky" appearance. The insecticide Diazinon 4E® is formulated as an emulsifiable concentrate. The active ingredient is dissolved in an oil-based solvent. When the product is mixed with water, an emulsion is formed. An emulsifying agent in the formulated product helps prevent the emulsion from separating by surrounding the oil droplets that contain the dissolved active ingredient to keep them from reuniting.

Familiarity with the different terms and processes described above will lead to a greater understanding and appreciation of the advantages and disadvantages of many commonly used pesticide formulations.

COMMON PESTICIDE FORMULATIONS AND SELECTION CONSIDERATIONS

The importance of formulation type is generally overlooked. A well-considered decision to use the most appropriate formulation for a given application will include an analysis of the following factors:

- **Applicator safety.** Different formulations present various degrees of hazard to the applicator. Some products are easily inhaled, while others readily penetrate skin, or cause injury when splashed in the eyes.
- **Environmental concerns.** Special precautions need to be taken with formulations that are prone to drift in air or move off target into water. Wildlife can also be affected to varying degrees by different formulations. Birds may be attracted by granules, and fish or aquatic invertebrates can prove especially sensitive to specific pesticide formulations such as 2,4-D esters.
- **Pest biology.** The growth habits and survival strategies of a pest will often determine what formulation provides optimum contact between the active ingredient and the pest.
- **Available application equipment.** Some pesticide formulations require specialized application equipment. This includes safety equipment, spill control equipment and, in special cases, containment structures.
- **Surfaces to be protected.** Applicators must be aware that certain formulations can stain fabrics, discolor linoleum, dissolve plastic, or burn foliage.

- **Cost.** Product prices may vary substantially, based on the ingredients used and the complexity of delivering active ingredients in specific formulations.

Individuals such as commercial pest control technicians or farmworkers who may not be involved in the selection process but are responsible for the actual application should also be very aware of the type of formulation they are using. As stated, formulation type can have an impact on hazards to human health and the environment. Inattention to the type of formulation being used could mean the difference between a routine application and one that is the source of environmental contamination—or worse, a serious human exposure.

Formulations are classified as solids or liquids on the basis of their physical state in the container at the time of purchase. A formulation can contain more than one active ingredient, and many have to be further diluted with an appropriate carrier (e.g., water) prior to use.

Solid Formulations

Solid formulations can be divided into two types: ready-to-use, and concentrates which must be mixed with water to be applied as a spray. The properties of six solid formulations are described in this publication. Three of the solid formulations (dusts, granules, and pellets) are ready-to-use, and three (wettable powders, dry flowables, and soluble powders) are intended to be mixed with water.

Dusts

Dusts are manufactured by the sorption of an active ingredient onto a finely-ground, solid inert such as talc,

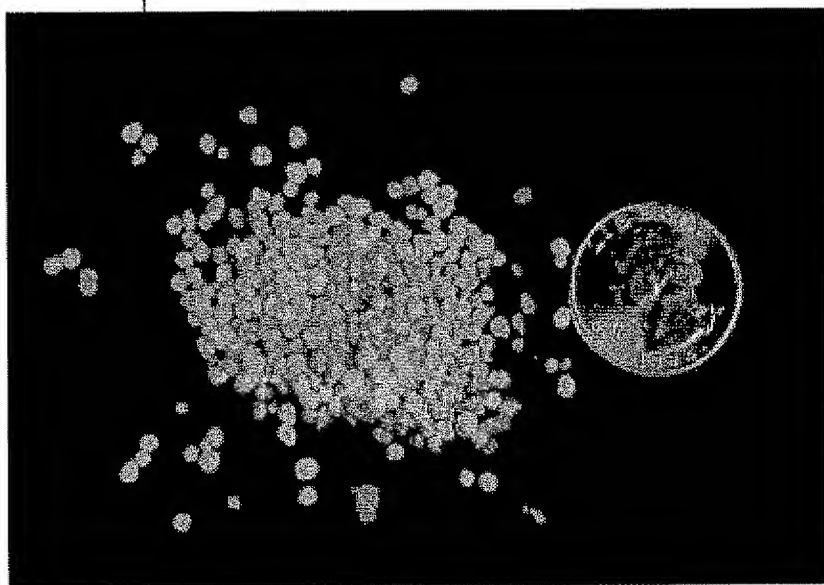


Dust

clay, or chalk. They are relatively easy to use because no mixing is required and the application equipment (e.g., hand bellows and bulb dusters) is lightweight and simple. Dusts can provide excellent coverage, but the small particle size that allows for this advantage also creates an inhalation and drift hazard. In general, dust formulations are no longer used in large scale outdoor situations due to their high drift potential. However, dusts are still applied as spot treatments for insect and disease control outside. Commercial pest control operators use dusts effectively in residential and institutional settings for control of various insect pests. Indoors, this type of formulation permits the delivery of an insecticide into cracks and crevices, behind baseboards and cabinets, etc. Thus, the insecticide is placed into the pest's habitat and away from contact by people and pets.

Granules

The manufacture of granular formulations is similar to that of dusts except that the active ingredient is sorbed onto a larger particle. The inert solid may be clay, sand, or ground plant materials. A granule is defined by size: Granule-sized products will pass through a 4-mesh (number of wires per inch) sieve and be retained on an 80-mesh sieve. Granules are applied dry and usually are intended for soil applications where they have the advantage of weight to carry them through foliage to the ground below. The larger particle size of granules, relative to dusts, minimizes the potential for drift. There is also a reduced inhalation hazard, but fines are associated with the formulation—especially when a bag is being emptied. In addition, granules have a low dermal hazard. The primary drawbacks of granules are their bulk, the problems they

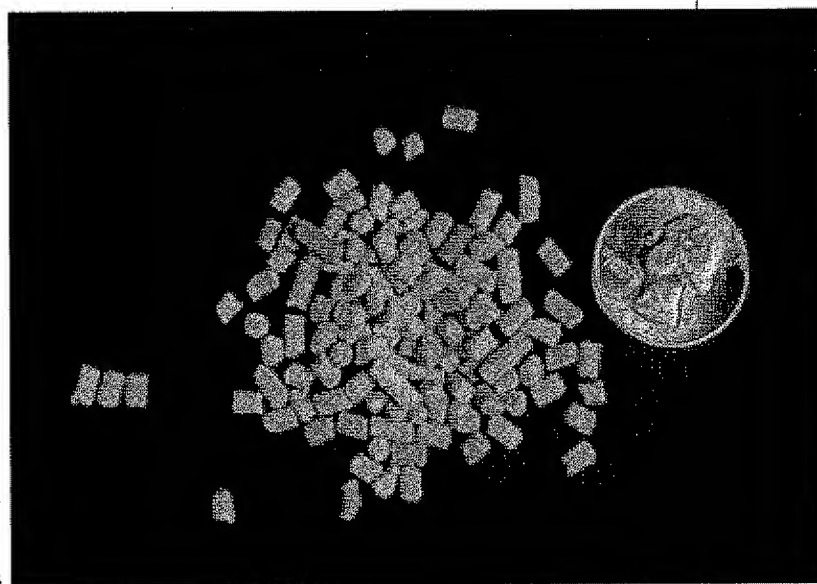


Granules

present in handling, and the difficulty inherent in achieving a uniform application with this type of product. Granules also may have to be incorporated into the soil to work, and they are sometimes attractive to nontarget organisms such as birds.

Pellets

Pellets are very similar to granules, but their manufacture is different. The active ingredient is combined with inert materials to form a slurry (a thick liquid mixture). This slurry is then extruded under pressure through a die and cut at desired lengths to produce a particle that is relatively uniform in size and shape. Pellets are typically used in spot applications. Pelleted formulations provide a high degree of safety to the applicator. They do have the potential to roll on steep



Pellets

or frozen slopes and thereby harm nontarget vegetation or contaminate surface water.

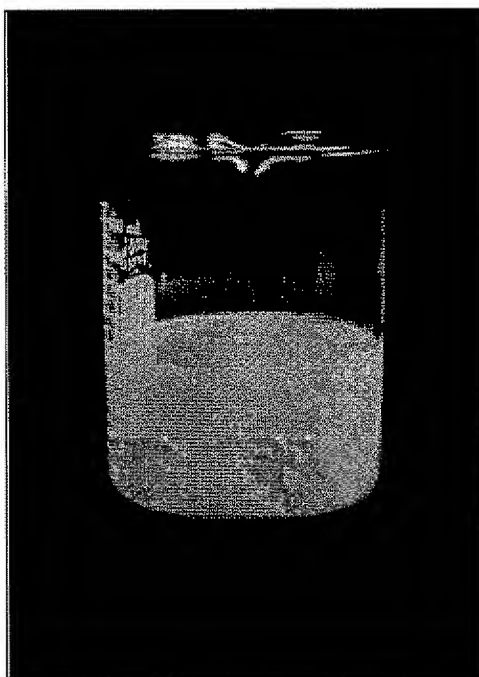
Wettable Powders

Wettable powders are finely divided solids, typically mineral clays, to which an active ingredient is sorbed. This formulation is diluted with water and applied as a liquid spray. Upon dilution, a suspension is formed in the spray tank. Wettable powders will likely contain wetting and dispersing agents as part of the formulation. These are chemicals used to help wet the powder and disperse it throughout the tank. Wettable powders are a very common type of formulation. They provide an ideal way to apply an active ingredient in spray form that is not readily soluble in water. Wettable powders tend to pose a lower dermal hazard in comparison to

liquid formulations, and they do not burn vegetation as readily as many oil-based formulations. This formulation does present an inhalation hazard to the applicator during mixing and loading because of the powdery nature of the particles. Furthermore, there are a series of disadvantages associated with *all* formulations that form a suspension in the spray tank: They require agitation to prevent settling out; they can be abrasive to equipment; and they may cause strainers and screens to plug.



Wettable powder
before mixing

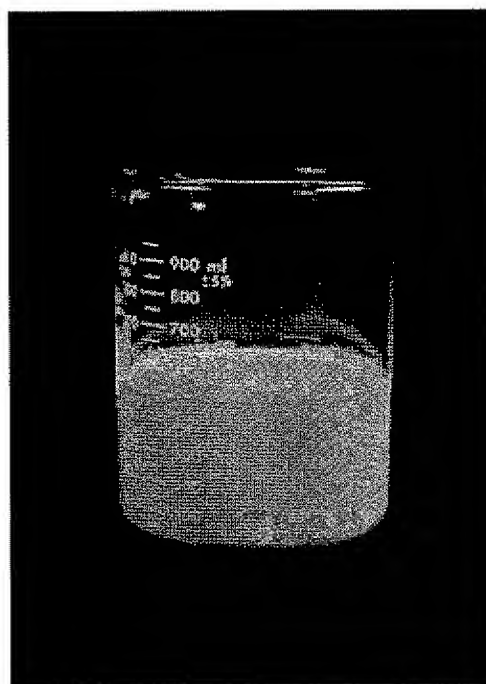
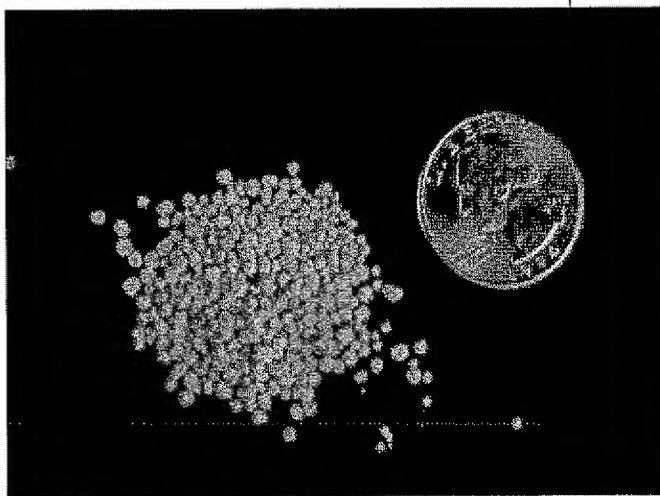


Wettable powder
after mixing

Dry Flowables

Dry flowables—or water dispersible granules, as they are sometimes called—are manufactured in the same way as wettable powders except that the powder

is aggregated into granular particles. They are diluted with water and applied in a spray exactly as if they were a wettable powder. Dry flowables, as would be expected, form a suspension in the spray tank; they have basically the same advantages and disadvantages as wettable powders, with several important exceptions. During the mixing and loading process, dry flowables pour more easily from the container and, because of their larger particle size, reduce inhalation hazard to the applicator.



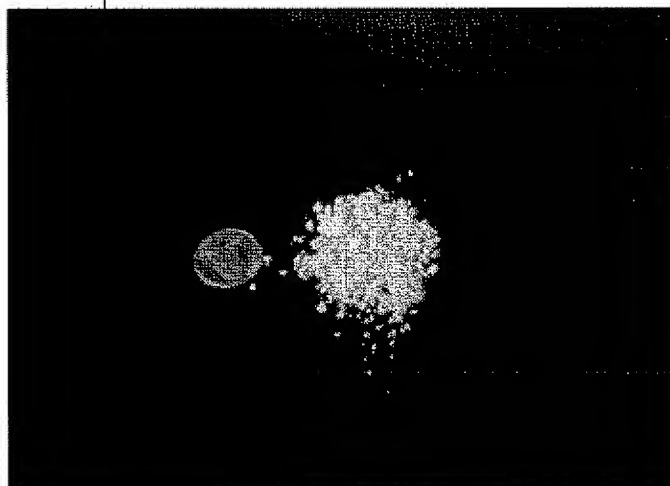
Dry flowable
before mixing

Dry flowable
after mixing

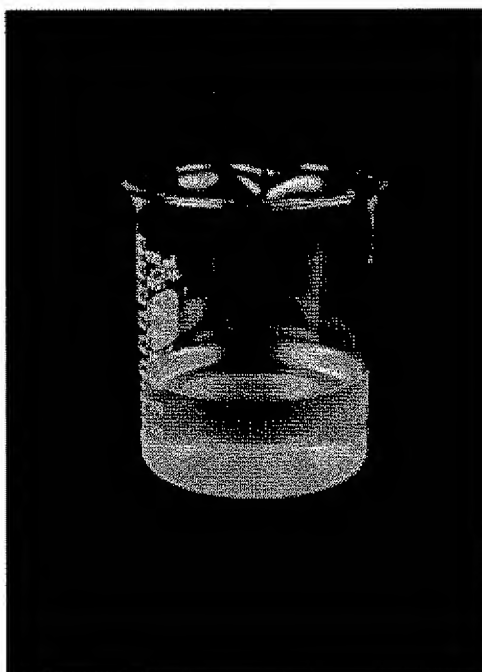
Note: The labels of some dry flowables do permit application of the product in the dry state.

Soluble Powders

Soluble powders, although not particularly common, are worth mentioning for purposes of contrast with the wettable powders and dry flowables. Their lack of availability is due to the fact that not many solid active ingredients are soluble in water. Those that do exist and are formulated in this fashion are mixed with water prior to spraying, dissolve in the spray tank, and form a true solution. Soluble powders provide most of the same benefits as wettable powders without the need for agitation once dissolved in the tank. They are also nonabrasive to application equipment. Soluble powders, like any finely divided particle, can present an inhalation hazard to applicators during mixing and loading.



Soluble powder
before mixing



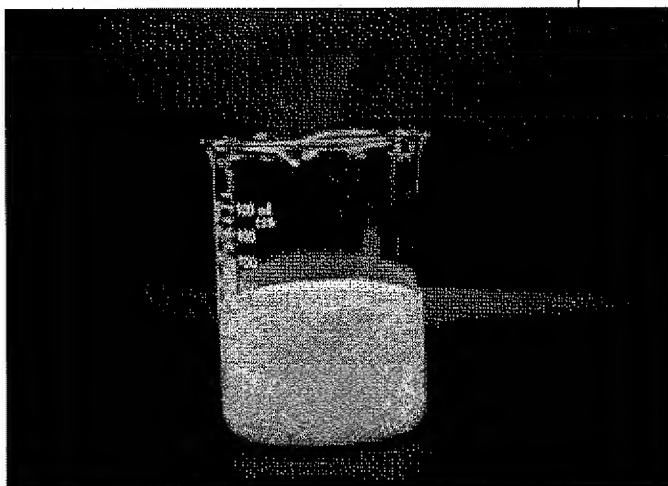
Soluble powder
after mixing

Liquid Formulations

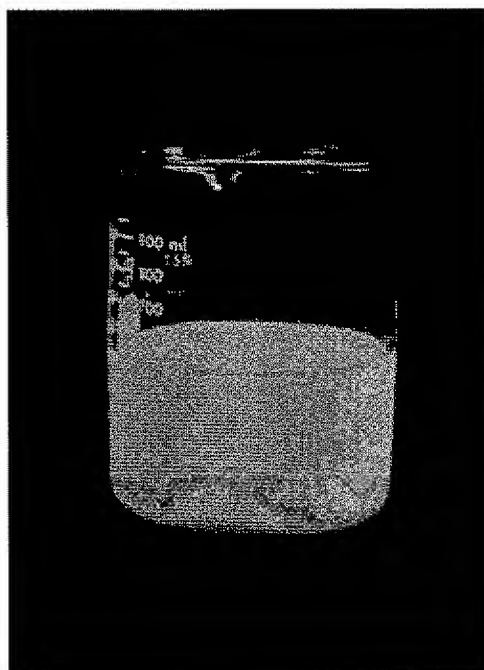
Descriptions of four, common liquid formulations that are mixed with a carrier follow. The carrier will generally be water, but in some instances labels may permit the use of crop oil, diesel fuel, kerosene, or some other light fuel oil as a carrier.

Liquid Flowables

The manufacture of liquid flowables (or flowables) mirrors that of wettable powders—with the additional step of mixing the powder, dispersing agents, wetting agents, etc., with water before packaging. The result is a suspension that is further diluted with water before use. The product is applied as a spray with all the advantages of a wettable powder. The benefit of this



Liquid flowable
before mixing

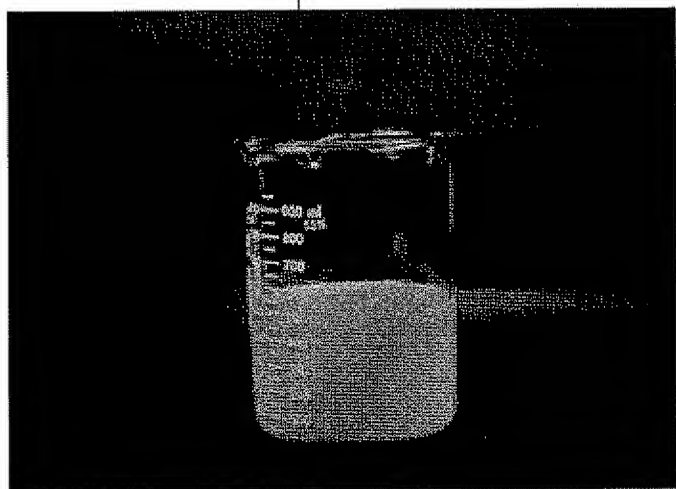


Liquid flowable
after mixing

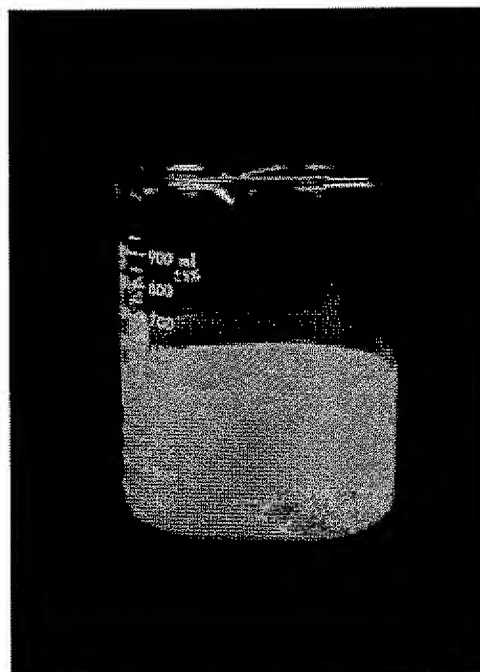
formulation is that there is no inhalation hazard to the applicator during mixing and loading since the powder already is suspended in water, permitting it to be poured. Liquid flowables form a suspension in the spray tank and have the same problems inherent in any suspension. However, they usually do not require agitation during application due to the extremely small size of the suspended particle but will settle if not tended to. One further problem noted with this formulation is the difficulty in removing all of the product from the container during mixing, loading, and container rinsing.

Microencapsulates

Microencapsulates consist of a solid or liquid inert (containing an active ingredient) surrounded by a plastic or starch coating. The resulting capsules can be aggregated to form dispersible granules (see dry flowables), or they can be suspended in water and the product sold as a liquid formulation. Encapsulation enhances applicator safety while providing timed release of the active ingredient. Liquid forms of microencapsulates are further diluted with water and applied as sprays. They form suspensions in the spray tank and have many of the same properties as liquid flowables.



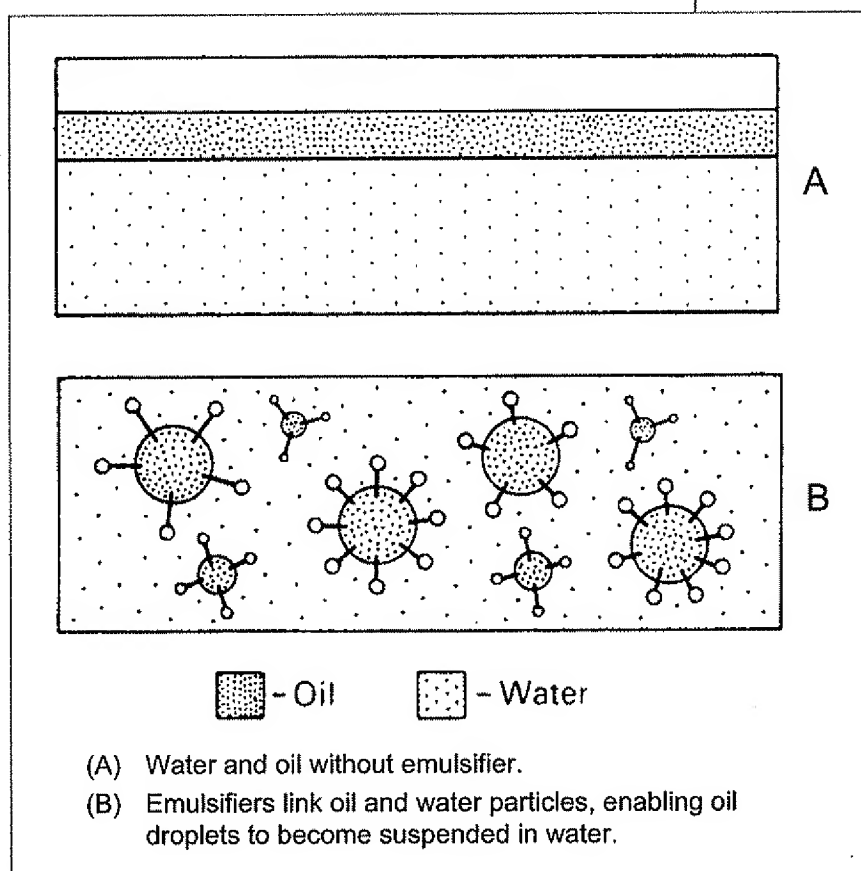
Microencapsulate
before mixing

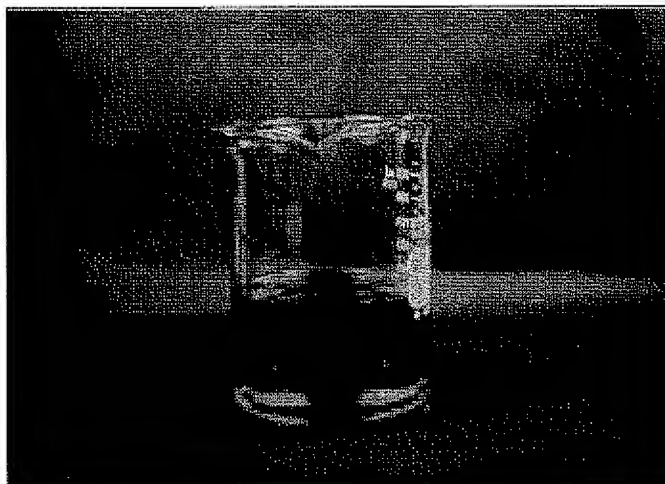


Microencapsulate
after mixing

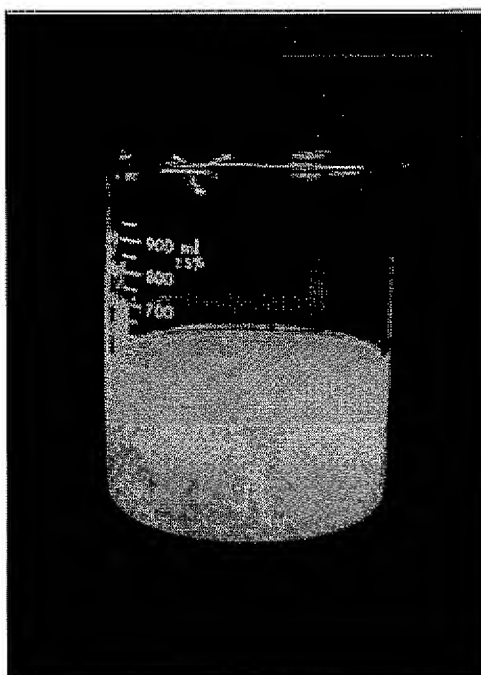
Emulsifiable Concentrates

Emulsifiable concentrates consist of an oil-soluble active ingredient dissolved in an appropriate oil-based solvent to which is added an emulsifying agent. Emulsifiable concentrates are mixed with water and applied as a spray. As their name implies, they form an emulsion in the spray tank. The emulsifying agents are long-chain chemicals that orient themselves around the droplets of oil and bind the oil-water surfaces together to prevent the oil and water from separating. Emulsifiable concentrates allow oil-soluble active ingredients to be sprayed in water as a carrier. Some agitation is typically required to maintain dispersion of the oil droplets. They are not abrasive to application equipment, nor do they plug screens and strainers. Emulsifiable concentrates have several disadvantages. There is a dermal hazard associated with this formulation. Emulsifiable concentrates readily penetrate oily barriers like human skin. They usually have an odor problem, and can also burn foliage and cause the deterioration of rubber and plastic equipment parts.





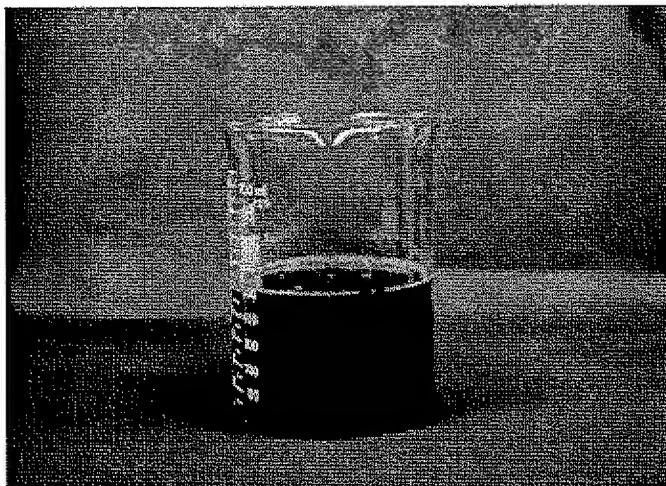
Emulsifiable
concentrate
before mixing



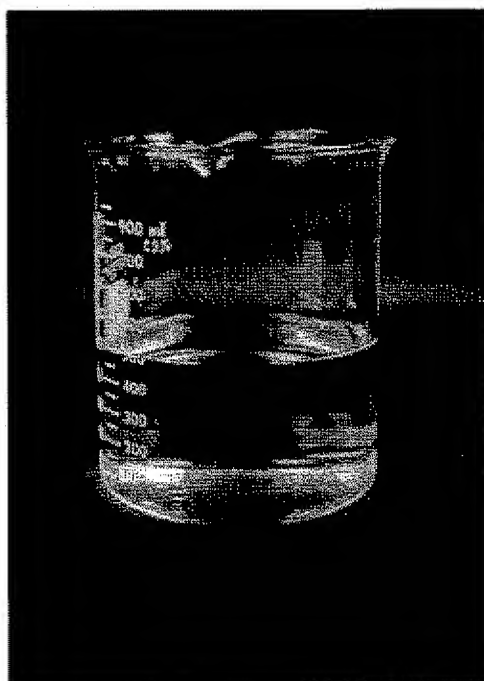
Emulsifiable
concentrate
after mixing

Solutions

Solutions (water-soluble concentrates) consist of water-soluble active ingredients dissolved in water for sale to the applicator for further dilution prior to field application. They will, obviously, form a true solution in the spray tank and require no agitation after they are thoroughly dissolved. Solutions are not abrasive to equipment and will not plug strainers and screens. Although not a particularly common formulation, several major herbicides with wide-scale use are formulated in this way. They include products containing paraquat, glyphosate and 2,4-D. Aside from lack of availability, solutions have few disadvantages; however, some that are produced as dissolved salts can be caustic to human skin.



Solution
before mixing

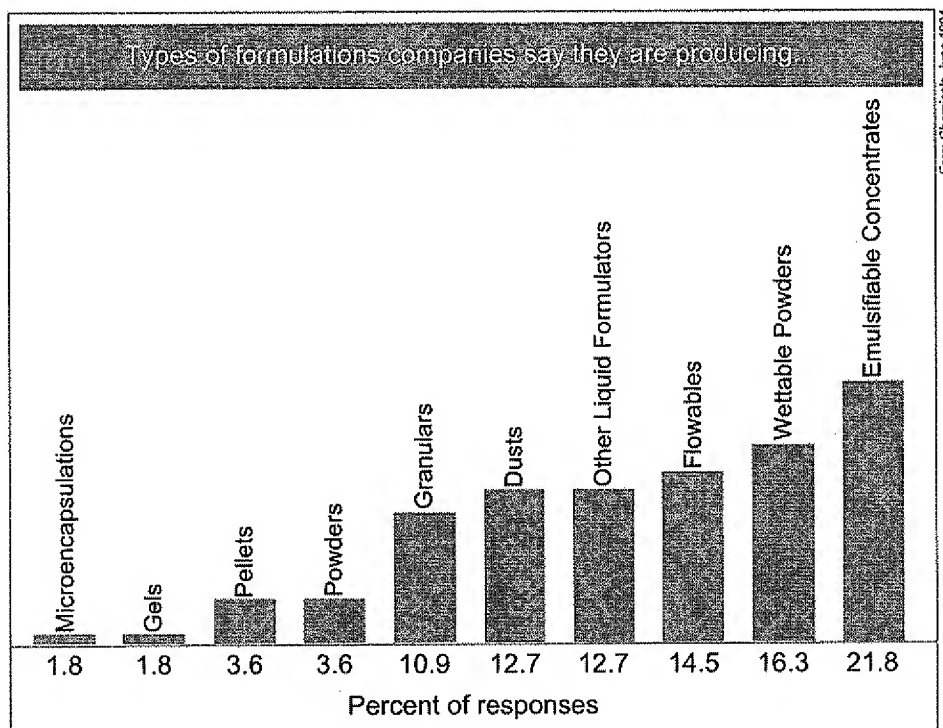


Solution
after mixing

Miscellaneous Liquid Formulations

Most liquid formulations are designed to be mixed with a carrier before application. However, some products are sold ready-to-use (RTU). This type of formulation generally will have a low concentration of active ingredient.

Low and ultra low volume concentrates used in specialty situations (e.g., space spraying and fogging) are frequently applied undiluted. Dermal hazards are a problem during mixing and loading of these products because of the high concentration of active ingredient. Low and ultra low volume concentrated formulations utilize special equipment to deliver the product in the form of very tiny droplets. Consequently, while they provide excellent coverage, drift potential and inhalation problems during application can be quite high.



Aerosols and Fumigants

These two formulations are frequently confused, yet they have very different properties and uses.

Aerosols really refer to a delivery system that moves the active ingredient to the target site in the form of a mist of very small particles: solids or liquid drops. The particles can be released under pressure or produced by fog or smoke generators. Aerosols are especially useful for indoor insect control, as coverage is thorough. It can be difficult to confine the aerosol to the target area, and there is always the danger of inhalation.

Fumigants deliver the active ingredient to the target site in the form of a gas. Some fumigants are solids that sublime (turn into a gas) in the presence of atmospheric moisture. Others are liquids under pressure that vaporize when the pressure is released. Fumigants can completely fill a space and many have tremendous penetrating power. They can be used to treat objects (e.g., furniture), structures, commodities, and even soil for pest insects and other vermin. Fumigants are among the most hazardous pesticide products to use due to their extreme inhalation danger.

FORMULATIONS AND LABEL INFORMATION

Product labels will often convey information about how the pesticide is formulated by a suffix to the brand or trade name. The table below lists many of these suffixes and their meanings. A suffix can also include a number that indicates the amount of active ingredient in the product. The number contained in the brand name suffix of a solid formulation such as a dust, granule, wettable powder, etc., describes the percent of active ingredient in that product on a percent by weight basis. For example, the brand name Sevin 50W® tells the purchaser that the product is formulated as a wettable powder (W) and that it is 50% active ingredient, *by weight*. The number included in the brand name suffix of a liquid formulation such as a liquid flowable (L) or an emulsifiable concentrate (EC) describes the amount of active ingredient in the product on the basis of *pounds per gallon*. The brand name Treflan 4EC® indicates that this product is formulated as an emulsifi-

| Suffixes of Chemical Brand Names | | | |
|----------------------------------|------------------------------|---|--|
| Suffix | Meaning | Suffix | Meaning |
| <i>Describe the formulation:</i> | | <i>Describe how a pesticide is used:</i> | |
| AF | Aqueous Flowable | GS | For Treatment of Grass Seed |
| AS | Aqueous Suspension | LSR | For Leaf Spot and Rust |
| D | Dust | PM | For Powdery Mildew |
| DF | Dry Flowable | RP | For Range and Pasture |
| E | Emulsifiable Concentrate | RTU | Ready-to-use |
| EC | Emulsifiable Concentrate | SD | For Use as a Side Dressing |
| ES | Emulsifiable Solution | TC | Termiticide Concentrate |
| F | Flowable | TG | Turfgrass Fungicide |
| FL | Flowable | WL | To Be Used with Weed Killers |
| G | Granule | <i>Describe characteristics of the formulation:</i> | |
| OL | Oil-Soluble Liquid | BE | The Butyl Ester of 2,4-D |
| P | Pelleted | D | An Ester of 2,4-D |
| PS | Pelleted | K | A Potassium Salt of the Active Ingredient |
| S | Soluble Powder | LO | Low Odor |
| SG | Sand Granules | LV | Low Volatility |
| SL | Slurry | MF | Modified Formulation |
| ULV | Ultra-Low Volume Concentrate | T | A Triazole |
| W | Wettable Powder | 2X | Double Strength |
| WDG | Water-Dispersible Granules | <i>Label for use in special locations:</i> | |
| WP | Wettable Powder | PNW | For Use in the Pacific Northwest |
| | | TVA | For Use in the Waterways of the Tennessee Valley Authority |

able concentrate and that it contains 4 *pounds* of active ingredient *per gallon* of product.

Exceptions to these rules of thumb common. Read the pesticide label carefully and consult the ingredient statement for a precise description of the active ingredient and its concentration.

NOVEL APPROACHES TO PESTICIDE PACKAGING

Pesticide packaging is receiving tremendous attention in today's markets. The traditional manufacturing approach is to package liquid formulations into nonrefillable plastic containers or to place granular materials into multilayered paper bags. State prohibitions against the burning of pesticide containers and pressures on the applicator to eliminate the disposing of plastic and paper containers in landfills have placed a premium on finding alternative packaging to replace small, one-way containers. The interest in and research on container management has spurred the development and implementation of a new generation of pesticide packaging and recycling programs to help stem the flow of plastic containers entering solid waste landfills.

Solutions to the Nonrefillable Plastic Jug

Pesticide Container Collection Programs

Recycling programs aimed at reducing the number of plastic pesticide containers thrown away in landfills have been conducted among many state agencies and industries associated with agricultural production. Pesticide applicators bring properly rinsed pesticide containers to a collection site for inspection. Containers meeting inspection standards are passed through a chipping machine and reduced to recoverable plastic pellets. Pesticide container collection programs have been responsible for eliminating millions of pounds of plastic that otherwise would have been landfilled.

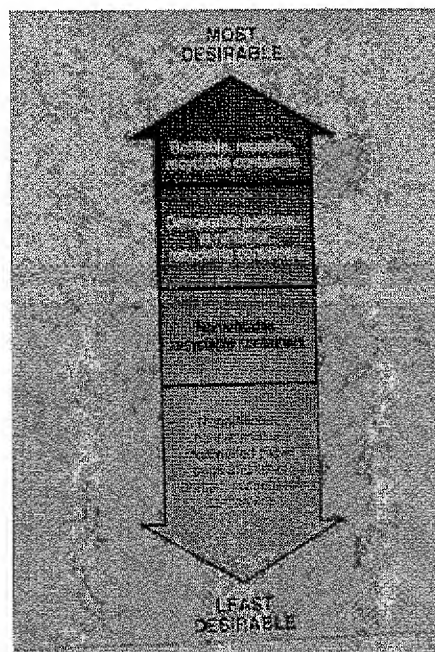
Returnable and Refillable Containers

Millions of 2 1/2-gallon plastic containers have been replaced with stainless steel tanks or plastic containers that hold larger volumes—5 - 250 gallons. These minibulk containers are transported to the site of application and, when emptied, are returned to the dealer or manufacturer for reprocessing and refilling. They are normally tamperproof, dedicated to a specific formulation, easily transported, and recyclable.

Water Soluble Packaging

Pesticide manufacturers are converting many products from a liquid formulation to a water-dispersible dry formulation, or incorporating them into a gel matrix. Both types of formulations are packaged in water-soluble pouches, with product and pouch enclosed in a moisture-proof bag or carton. The applicator tears off t

the outside protective cover and places the water-soluble bag into the spray tank. The bag dissolves and releases the dry or gel formulation into the water. The benefits of water-soluble packaging include limited exposure to the concentrated pesticides, elimination of the container rinsing process, enhanced emergency spill response, and reduction of the amount of waste placed in landfills.



Closed Granular Chemical Handling System

Granular formulations are packaged into multilayered paper bags. Recycling multilayered bags is difficult because the paper, foil, and, plastic layers prove difficult in separating and impossible in rinsing. One innovative approach has been to place the granular material into a closed pesticide handling system that mounts directly to the lid of the farmer's planter box. The container is returned to the supplier for refill. The solutions provided by the closed granular container systems are twofold: reduced applicator exposure, and the elimination of the multilayered paper bag.

SYNERGISTS

Synergists are chemicals that can boost the pesticidal activity of an active ingredient. The combination of a synergist with the active ingredient provides a degree of pest control greater than what would be expected from the simple additive effects from each compound. Synergists are used with a variety of pesticides including insecticides, nematicides, and fungicides. Synergists typically have little, if any, activity against the pest when used alone. However, EPA policy is to include synergists in the active ingredient statement on the product label.

A common example of a synergist is piperonyl butoxide. This chemical synergizes pyrethrin insecticides. It is believed to function by slowing down the insect pest's ability to metabolize (detoxify) pyrethrin resulting in fewer insects recovering from exposure to the insecticide.

ADJUVANTS

An adjuvant is *any* compound that facilitates the action of pesticides or modifies characteristics of pesticide formulations or spray solutions. The terminology for pesticide additives is confusing. It is often assumed that any material that lowers the surface tension of water (i.e., a surfactant) in the spray mixture or increases the wettability of the spray solution on surfaces is an adjuvant.

Adjuvants are used in pesticide spray solutions as

- wetting agents
- penetrants
- spreaders
- co-solvents
- stickers
- stabilizing agents

It is obvious that the term *adjuvant* encompasses a wider meaning than wetting agent or surfactant. There are many adjuvants that have little, if any, effect on pesticidal activity.

These types of adjuvants include

- anti-foam agents
- buffering agents
- compatibility agents
- liquid fertilizer/herbicide mixtures

Adjuvants are included in pesticide formulations as part of the total product which is sold by the manufacturer or as an additive to be mixed with pesticide products in the spray tank. Adjuvants can be classified according to their type of action.

There are three basic types of adjuvants used with pesticides:

- Activator adjuvants include surfactants, wetting agents, penetrants, and oils. Activator agents are the best known class of adjuvants because they are normally purchased separately by the user and added to the pesticidal solution in the spray tank.
- Spray modifier agents include stickers, film formers, spreaders, spreader/stickers, deposit builders, thickening agents, and foams.
- Utility modifiers include emulsifiers, dispersants, stabilizing agents, coupling agents, co-solvents, compatibility agents, and anti-foam agents.

Spray modifier agents and utility modifier agents are usually found as part of the pesticide formulation and thus are added to the pesticide product by the manufacturer.

SUMMARY

Becoming informed about the benefits and problems associated with the various pesticide formulations does not require a significant amount of memorization. Application of some basic principles of chemistry and consideration of formulation particle size can lead to some very accurate judgements about formulation properties. Several themes developed in this publication can be used to construct a planning or decision-making model.

The proper selection of a formulation is a critical step in any pest control process involving pesticides. It is an important management decision that has an impact on profitability, human safety, and environmental quality. An understanding of the properties of various formulations has as much significance to the applicator as it does to the supervisor. The applicator performs the duties of mixing and loading as well as application. Applicators come into close contact with both the concentrated and diluted product. A simple, personal interest in one's continued good health dictates the need to know the safety properties of the formulation being used. Furthermore, a concern for environmental quality reflected in a responsible application requires a familiarity with the attributes of a given formulation and the potential impact its use might have on the surroundings.

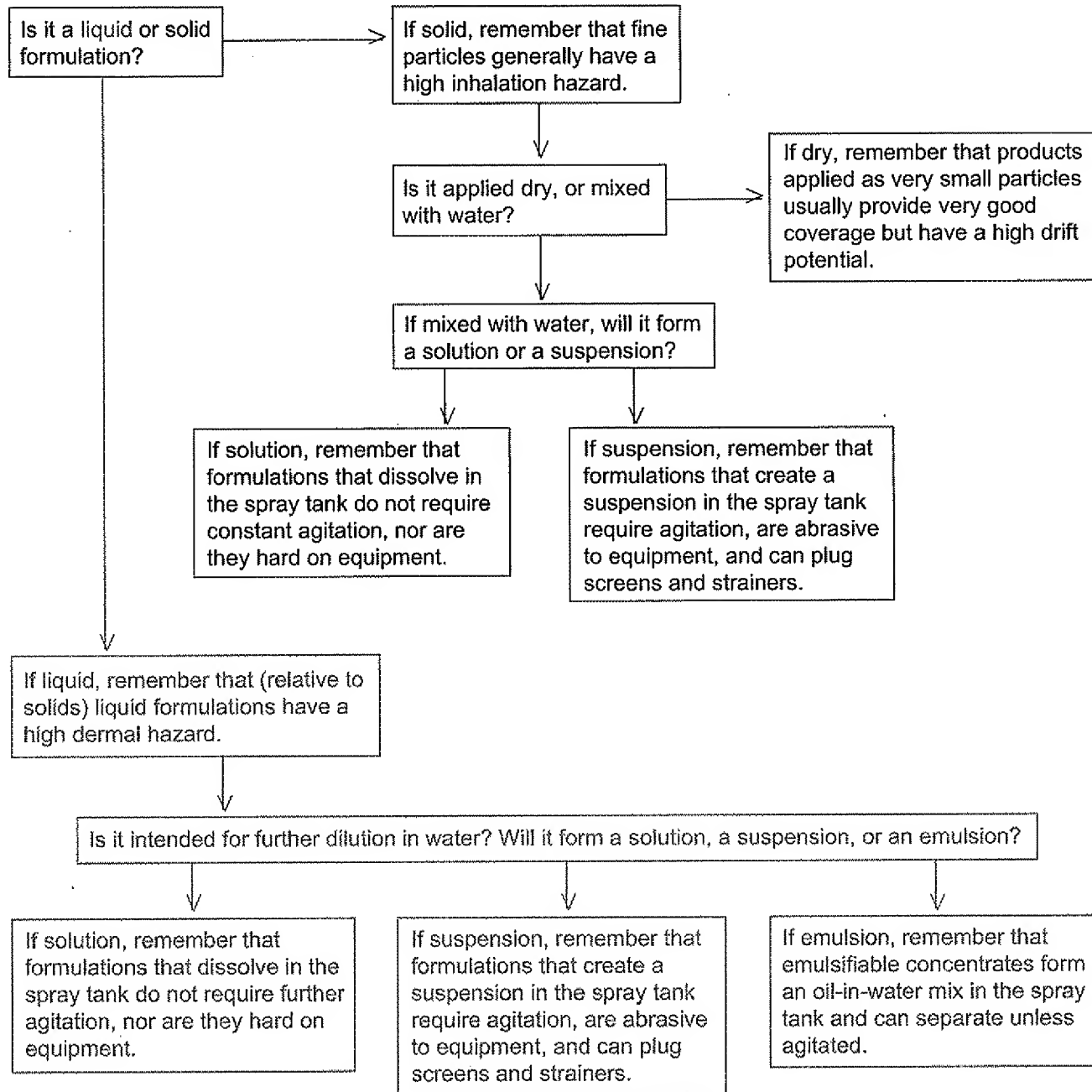
No endorsement of named products by the authors or Purdue University is intended, nor is criticism implied for products that are not mentioned. Always follow the directions on the label. Many different formulations and combinations of these materials are sold under various trade names, and the quantity of use will vary with the formulation obtained.

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Ask yourself the following questions when selecting or using a pesticide formulation:



All liquid applications that produce tiny droplets can provide very good coverage but have high inhalation and drift hazards.

Reviewed 5/01

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EMULSIFIABLE CONCENTRATES - 3.2

| Active Ingredients | | Emulsifiers | | | | | Stabilizers and solvents | | |
|--------------------|------|-------------|------|-----|-------|------|--------------------------|--------------------------------|-----------|
| | | FF/4 | FF/6 | MS | V/497 | V/87 | --- | --- | Xylene |
| Endosulfan | 35 | 1,8 | | 3,2 | | | | EPO. 2 | up to 100 |
| Ethion | 50 | 3,5 | | 1,5 | | | | | up to 100 |
| Fenitrothion | 50 | 2,3 | | | 5,7 | | | | up to 100 |
| Lindane | 25 | 2,0 | | 3,0 | | | | Cyclohexanone 25 | up to 100 |
| Malathion | 50 | 1,8 | | | 3,2 | | | | up to 100 |
| Malathion | 57 | 2,5 | | 2,5 | | | | | up to 100 |
| Mollinate | 72,5 | 2,3 | | | | | RE/70 : 2,7 | | up to 100 |
| Parathion | 50 | 1,7 | 3,3 | | | | | | up to 100 |
| Parathion Methyl | 50 | 3,5 | | | | | RE/70 : 4,5 | | up to 100 |
| Pendimethalin | 33,7 | 4,7 | | | | 2,3 | | | up to 100 |
| Phenmediphan | 15,9 | | | | | | VB/55-N: 20 | Isophorone up to 100 | |
| Permethrin | 5 | 2,7 | | 3,3 | | | | | up to 100 |
| Permethrin | 25 | 3,0 | | 3,0 | | | | | up to 100 |
| Permethrin | 5 | 3,3 | | 2,7 | | | | | up to 100 |
| Permethrin | 25 | 3,6 | | 2,4 | | | | | up to 100 |
| Propanil | 35 | | | | | | PR/500 : 16 | Isophorone or Cyclohexanone 30 | up to 100 |
| Tetradifon | 8 | 2,3 | | 2,7 | | | | | up to 100 |
| Thiobencarb | 50 | 2,3 | | 2,7 | | | | | up to 100 |
| Toxaphene | 75 | 3,0 | | 2,0 | | | | EPO 2 | up to 100 |
| Trifluralin | 48 | 5,3 | | 1,7 | | | | | up to 100 |

Legenda: EPO - Epoxidized soybean oil
 MCB - Monochlorobenzene

For specific tradenames see pag. 65 Data Sheets 5.2

Above mentioned compositions are general examples; specific formulations are available on request.